

SONOGRAPHIC EVALUATION OF CAROTID INTIMA MEDIA THICKNESS (cIMT) IN ADULT DIABETIC PATIENTS IN UNIVERSITY OF MAIDUGURI TEACHING HOSPITAL, NORTH EASTERN NIGERIA

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ABSTRACT

Background: Intima media thickness of the carotid arteries has been used as a subclinical index of atherosclerosis in patients with diabetes mellitus and has also been used in epidemiological and interventional studies as a surrogate index of atherosclerosis. However, to date, there is paucity of data on sonographic carotid artery intima media thickness (IMT) measurements and the prevalence of carotid atherosclerosis and stenosis among adult diabetic patients in our environment. **Objective:** The objective of this study was to evaluate carotid artery intima media thickness among adult diabetic patients using carotid duplex ultrasonography (CDUS). **Methods:** This was a cross-sectional study carried out at the University of Maiduguri Teaching Hospital, Nigeria. One hundred and twenty adult diabetic patients aged 20 - 78 years had CDUS for measurements of carotid artery intima media thickness. Measurements were taken at 1cm below and 1cm above the carotid bulb for the common carotid (CCA) and internal carotid arteries (ICA) respectively. Pearson's correlation and Student t-test were used to compare the means between the variables. **Results:** There were 72(60%) male and 48(40%) female diabetic patients aged 20 to 78 years (mean = 50.03±11.4 years). Mean intima-media thickness, in millimeters (mm), for normal (non-stenotic) carotid arteries on the right and left were (CCA=0.71±0.09 and 0.70±0.08; ICA=0.71±0.08 and 0.69±0.09) and abnormal (stenotic) on the right and left were (CCA=0.84±0.17 and 0.83±0.19; ICA=0.98±0.10 and 1.03±0.10) respectively. A total of 75 patients (62.5% of study population) had no carotid artery stenosis; 38 patients (31.7%) had <50% carotid stenosis; 6 patients (5.0%) had 50-69% carotid stenosis; and 1 patient (0.8%) had 72% carotid stenosis. The prevalence of carotid stenosis in diabetic patients was 37.5% in this study. There was positive and significant correlation between percentage degree of stenosis with IMT ($r = +0.5$; $p < 0.05$). **Conclusion:** The findings of this study have indicated the presence of atherosclerotic and haemodynamic changes in the carotid arteries of adult diabetic patients in this environment who are at risk of developing stroke from carotid stenosis. CDUS has proved to be a valuable diagnostic and screening tool in the evaluation of these patients because of its safety, low cost, wide availability, and accuracy in detecting carotid artery disease.

KEYWORDS: Carotid arteries; diabetes mellitus; intima-media thickness; atherosclerosis; Doppler Ultrasound scan.

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INTRODUCTION

Diabetes Mellitus (DM) is a well known modifiable risk factor for cardiovascular diseases^{1,2} and ischaemic stroke³. Diabetic patients have 2 to 5-fold increased risk for stroke compared with those without diabetes^{2,4}, and the main underlying cause of stroke is carotid atherosclerosis^{2,5,6} leading to carotid stenosis¹ with most changes affecting the carotid bifurcation⁷.

The ability to predict future strokes in asymptomatic patients with carotid stenosis is currently limited; therefore, identification and treatment of risk factors for stroke have become necessary over the past decade⁸. Although there is paucity of data on prevalence of diabetes in Nigeria and other African countries, available data suggest that diabetes is emerging as a major health problem in Africa, including Nigeria⁹. A study by Gezawa¹⁰ reported a 7% prevalence of diabetes in Maiduguri.

Carotid arteries are the major vessels that transport oxygenated blood to the brain. Carotid duplex ultrasound (CDUS) is a non-invasive, safe and relatively inexpensive technique for evaluating the carotid arteries¹¹. CDUS uses B-mode ultrasound imaging and Doppler ultrasound to detect carotid intima media thickness (cIMT)¹¹⁻¹³. Complementary to ultrasound scan are other imaging modalities^{14,15}; including conventional angiography, magnetic resonance angiography (MRA), and contrast enhanced dynamic computed tomography which provide an assessment of carotid luminal size but are unable to characterize the vessel wall or associated plaques¹⁶. Angiography though considered as the gold standard is an invasive procedure^{17,18}. In addition, conventional angiography and computed tomography angiography (CTA) uses ionizing radiation. Moreover, CDUS can detect both early and advanced atherosclerotic disease, in addition to its central role in many recent epidemiological studies targeted at

atherosclerotic prevention trials¹⁹. Although angiography, CTA and MRA are complementary to ultrasound their usefulness is limited by the need for sophisticated equipment and accompanying radiation exposure involved in CT and angiography. They are also expensive and may not be readily available for it to be applied to large populations in a developing country.

Husni²⁰ reported that diabetes mellitus (DM) promotes atherosclerosis of the carotid arteries and may increase hypertension, hyperlipidaemia and coronary heart disease, which are also risk factors for developing stroke. Studies among Nigerians and other populations in developed countries have confirmed diabetes^{4,21} hypertension^{22,23} increasing age²⁴ dyslipidaemia^{25,26} cigarette smoking, heavy alcohol consumption, obesity, anaemia, HIV infection and congestive cardiac failure^{21,23,27} as the most dominant risk factors for stroke. The identification and understanding of the magnitude of these stroke risk factors will go a long way in stroke prevention²⁸. Diabetes mellitus has been reported to significantly increase risk of stroke following atherosclerosis of the carotid arteries⁴ and up to 20-37% of patients with stroke have been documented as diabetic²².

Olson²⁹ described a technique in 1974 depicting ultrasonography as an imaging modality to monitor the instantaneous diameter, wall thickness, and blood flow of the human carotid arteries. The feasibility of using carotid ultrasonography in a large multicentre study with excellent reproducibility for CCA and acceptable reproducibility for the ICA IMT measurements have also been reported³⁰. Carotid ultrasonography, measuring both the presence of stenosis and IMT, has provided a powerful non-invasive technique to determine atherosclerosis³¹ and carotid IMT (cIMT) has been extensively used as an outcome measure in clinical trials³²⁻³⁴.



Pignoli³⁵ defined IMT as the distance from the leading edge of the first echogenic line to the leading edge of the second echogenic line with the first line representing the lumen-intimal interface; the collagen-containing upper layer. The minimum measured IMT in the CCA and ICA was 0.2mm and the maximum was 0.9mm and IMT was noted to be significantly lower in women than in men³⁶. Handa et al⁶ evaluated healthy Japanese subjects and found a maximum IMT complex of < 1.0mm and, therefore, defined carotid atherosclerosis as an IMT complex of > 1.0mm. The normal thickness of the intima-media complex measured in the B-mode is 0.5–0.6 mm³⁷. However, the 2003 consensus conference of the society of Radiologist in ultrasound recommends that, the IMT in CCA and ICA in adults are as follows: normal CCA IMT <0.87mm; normal ICA IMT <0.90mm³⁸. These values for IMT were noted to be higher in men than women^{15,37}.

Brian³⁹ stated that CCA IMT greater than 0.87mm and ICA IMT greater than 0.90mm were associated with progressively increased risk of cardiovascular events, and that for each 0.20mm increase in CCA IMT, the risk increased by approximately 27% and for each 0.55mm increase in ICA IMT, the risk increased approximately 30%.

The increasing frequency of diabetes mellitus in our environment and the absence of data on CCA and ICA intima media thickness necessitated this study. The results of this study may be used for detecting early atherosclerosis in the CCA and ICA and possibly predict clinical complications in adult diabetic patients.

MATERIALS AND METHODS

Study design: This was a hospital based cross-sectional study. Subjects were recruited consecutively from the Endocrinology Unit of the Department of Internal Medicine University of Maiduguri Teaching Hospital (UMTH) based on the inclusion criteria stated

below using simple random sampling until the sample size was reached.

Study area: The study was carried out at the Department of Radiology UMTH Maiduguri, Nigeria.

Sample size estimation: This was done using Tailor's formula⁴⁰.

$$n = z^2 pq / d^2$$

Where:

n = the desired sample size (when the population is greater than 10,000)

z = the standard normal deviate, usually set at 1.96 (or more simply 2.0), which corresponds to 95 percent confidence level.

p = the proportion in the target population estimated to have a particular characteristic.

The prevalence of diabetes in Maiduguri (2009) 10 stands at 7% (i.e. 0.07)

$$q = 1.0 - p \text{ (i.e. } 1 - 0.07)$$

d = degree of accuracy desired, usually set at 0.05

$$\text{Therefore: } n = z^2 pq / d^2$$

$$= (2.0)^2 (0.07) (1 - 0.07) / (0.05)^2$$

$$= (4.0) (0.07) (0.93) / (0.0025)$$

$$= 0.26 / 0.0025$$

$$= 104$$

However, the sample size was increased to 120 to further increase the sensitivity of the study.

Study population: This study was conducted on adult male and female patients with type-2 diabetes mellitus, aged 20 years and above who met the inclusion criteria and volunteered to participate in the study. The subjects were recruited consecutively at random from the Endocrinology Unit of the Department of Internal Medicine UMTH.

Inclusion criteria

1. Consenting adult diabetic patients aged 20 years and above.
2. Diabetic patients with fasting blood glucose (FBG) level of ≥ 7.0 mmol/L

Exclusion criteria

1. Subject below 20 years of age.
2. Pregnant women because of physiological



changes and accompanying dilatation of the CCA.

3. Patients with known systemic vascular disease other than diabetes mellitus.
4. Patients with stroke or past history of cerebrovascular disease.

The study was carried out on 120 adult type-2 diabetic patients aged 20 years and above who voluntarily participated in the study. After explaining the examination/procedure to the patient he/she was asked to wear comfortable loose fitting clothing and remove all jewellery around the area to be examined. A brief history to include previous cardiovascular disease was taken.

The examination was performed using a high-resolution real-time Doppler ultrasound scanner (Aloka, SSD-3500) equipped with 7.5 and 10MHz linear-array transducer. The high frequency transducer provides greater resolution for superficial structures such as the carotid artery.

With the patient in a supine position, the shoulder was placed on pillow with the neck extended and turned slightly away from the side being scanned. After applying ultrasound gel to the neck, the transducer was placed above the clavicle in a transverse position initially for the grey-scale examination.

The CCA was located and followed proximally as far as the clavicle permitted. The transducer was moved cephalad following the CCA to the level of the carotid bifurcation (thyroid cartilage). The internal carotid artery was then followed distally to the angle of the mandible.

The IMT measurements were obtained at 1cm below the carotid bulb for CCA and 1cm above the carotid bulb for ICA (Figure 1). Longitudinal and transverse views were done in colour Doppler (Figure 2). A single measurement was recorded at each location for intima media thickness which was taken as the distance between the leading edges of the lumen-intima interface and the media-adventitia interface of the far wall (Figures 3).

The degree of stenosis was determined using the NASCET methodology^{41,42} where the measured maximum flow velocity and the local narrowing in percent diameter reduction at the maximum of the stenosis were calculated according to the formula $[1-(s/n)] \times 100\%$, where s represents the tightest diameter of stenosis and n the suspected former vessel diameter (Figure 4). For the purpose of this study, the classification for degree of stenosis in CCA and ICA of the Society for Radiologists in Ultrasound (SRU) as reported by Grant et al³⁸ was used.

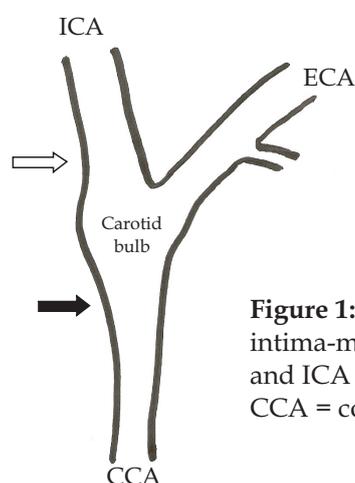


Figure 1: Points of measurements for diameter, intima-media thickness (IMT) in the CCA (black arrow) and ICA (grey arrow). ECA = External carotid artery; CCA = common carotid artery; ICA = Internal carotid artery.

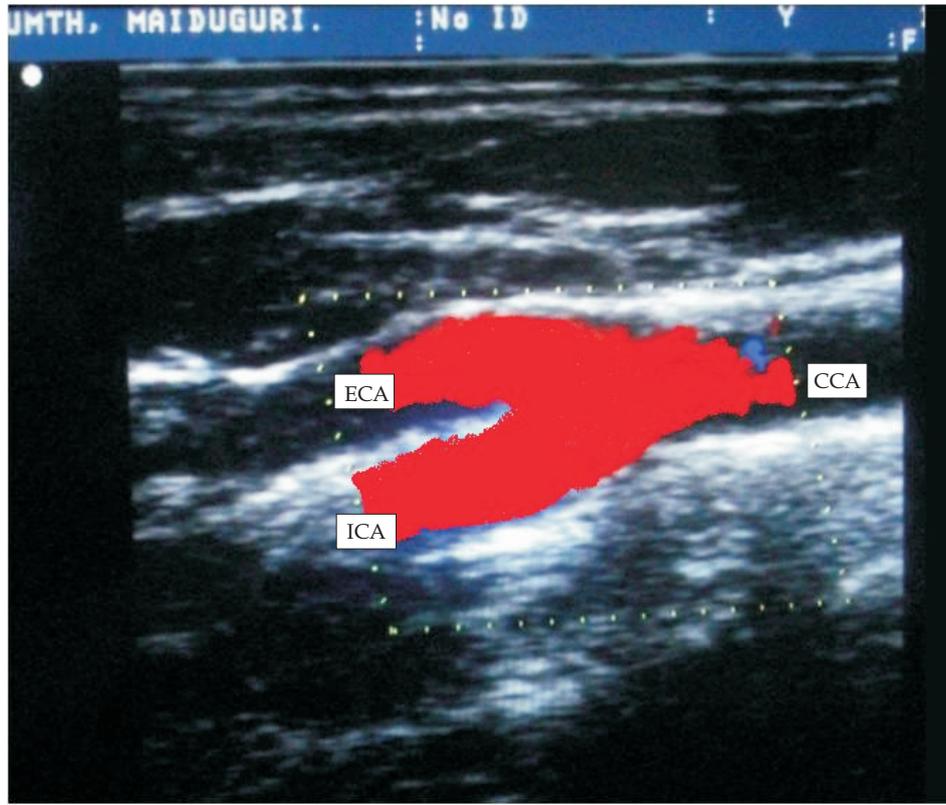


Figure 2: Colour Doppler image (longitudinal view) of the common carotid artery (CCA) and bifurcation into the internal carotid artery (ICA) and external carotid artery (ECA).

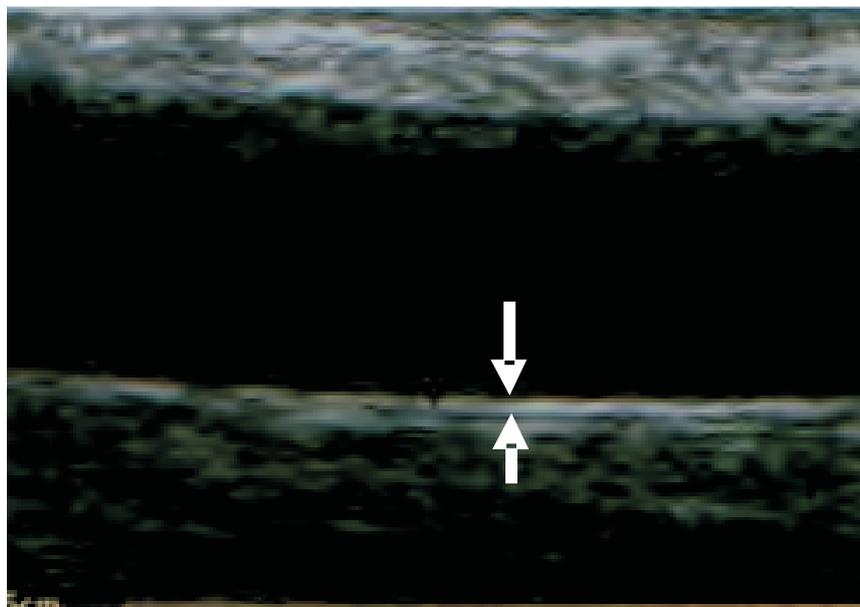


Figure 3: Gray-scale ultrasonography of CCA (longitudinal view) showing point of measurement for IMT.

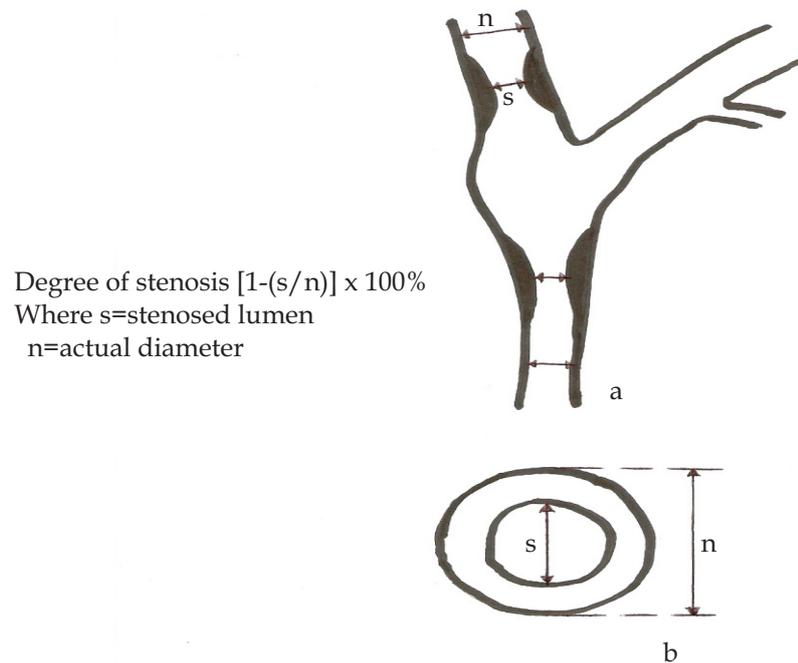


Figure 4: Method for calculating the degree of stenosis in the carotid arteries adapted from Tola *et al*⁴¹ and NASCET⁴².

Statistical analysis: The data obtained from the structured data sheet were processed and analysed using the Statistical Package for the Social Sciences (SPSS) for Windows® version 16.0 (SPSS Inc; IL, USA). The results were summarized and expressed as mean \pm standard deviation (SD) and presented in the form of tables, graphs and charts as appropriate.

Statistical significance was assessed using Students t-test (2-tailed) to compare the mean carotid artery intima-media thickness between the genders in the population studied. Correlation between percentage degrees of stenosis with intima-media thickness (IMT) was evaluated using Pearson's correlation test. P-value of 0.05 was considered statistically significant.

Ethical consideration: This study was conducted with adherence to ethical standards. Informed written consent was obtained from the subjects before enlistment into the study. Approval to carry out the study was obtained from the Ethical Committee of the University of Maiduguri Teaching

Hospital. The subjects were informed of the safety of ultrasound scan and could withdraw from the study at any stage without consequences. The data collected from the participants were recorded serially and kept with utmost confidentiality according to medical practice.

RESULTS

A total of 120 adult diabetic patients aged 20 years and above were enrolled into this prospective cross-sectional hospital based study. Seventy two (60%) were males and forty eight (40%) were females (Figure 5).

The age range was 20 - 78 years with a mean (\pm SD) of 50.03 \pm 11.4 years. The mean age for males was 51.97 \pm 10.39 years, while for females was 47.10 \pm 11.70 years. The predominant age group in both sexes was 40 - 49 years (35% of the total sample size) with the males having the highest frequency of 24 patients in that age group (20% of the study population). The modal age group for the study was also 40 - 49 years totalling 42 patients (35% of the total sample population) as shown in table 1.

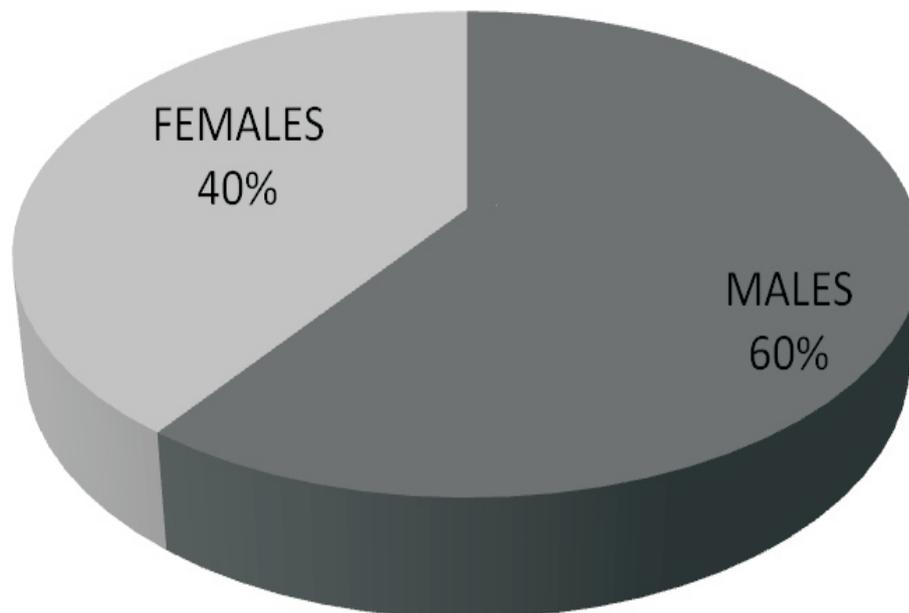


Figure 5: Pie-chart showing sex distribution of the study population

Table 1: Age-Sex Distribution pattern of study population

Age group (Years)	Males n (%)	Females n (%)	Total N (%)
20-29	2 (1.7)	4 (3.3)	6 (5.0)
30-39	9 (7.5)	9 (7.5)	19 (15.0)
40-49	24 (20.0)	18 (15.0)	42 (35.0)
50-59	19 (15.8)	10 (8.3)	29 (24.1)
60-69	14 (11.7)	5 (4.2)	19 (15.9)
70-79	4 (3.3)	2 (1.7)	6 (5.0)
Total	72 (60)	48 (40)	120 (100)

N = Sample population

The mean intima-media thickness (IMT), in millimeters (mm) of carotid arteries in the different age groups of males and females studied is shown in table 2. Forty-two diabetic patients (35% of the study population) in their 5th decade were observed to have the highest mean IMT; RCCA (0.95±0.24mm), LCCA (0.91±0.20mm), RICA (0.92±0.19mm), LICA (0.89±0.19mm) for the males, and RCCA (0.92±0.85mm), LCCA (0.90±0.77mm), RICA

(0.90±0.66mm), LICA (0.89±0.58) for the female patients in that age group.

Observed mean IMT values in males were higher than their female counterparts in the same age group. Right carotid arteries had higher mean IMT than the left, although these differences in mean IMT between the right and left were not statistically significant (p=0.07).

Table 2: Age distribution pattern of intima-media thickness (IMT) in carotid arteries of diabetic patients

IMT mean±SD (mm)	20-29 yrs.	30-39 yrs.	40-49 yrs.	50-59 yrs.	60-69 yrs.	70-79 yrs.	Total
RCCA	0.77±0.09	0.75±0.07	0.95±0.24	0.90±0.16	0.88±0.17	0.86±0.06	0.85±0.13
Males	0.65±0.03	0.73±0.07	0.92±0.85	0.80±0.06	0.81±0.01	0.85±0.28	0.79±0.22
Females							
LCCA	0.75±0.10	0.73±0.11	0.91±0.20	0.89±0.18	0.88±0.20	0.84±0.09	0.83±0.15
Males	0.64±0.05	0.72±0.09	0.90±0.77	0.80±0.10	0.80±0.12	0.84±0.25	0.78±0.23
Females							
Total (N)	6	18	42	29	19	6	120
RICA	0.73±0.03	0.73±0.12	0.92±0.19	0.87±0.21	0.88±0.30	0.89±0.05	0.84±0.15
Males	0.60±0.04	0.70±0.12	0.90±0.66	0.72±0.14	0.80±0.21	0.81±0.13	0.76±0.22
Females							
LICA	0.65±0.07	0.72±0.11	0.89±0.17	0.85±0.18	0.88±0.26	0.89±0.08	0.81±0.15
Males	0.60±0.12	0.65±0.33	0.89±0.58	0.71±0.20	0.79±0.50	0.80±0.38	0.74±0.035
Females							
Total (N)	6	18	42	29	19	6	120

SD = Standard deviation; **RCCA**= Right common carotid artery; **LCCA**= Left common carotid artery; **RICA**= Right internal carotid artery; **LICA**= Left internal carotid artery; **N**= Sample population.

Tables 3 show that a total of 480 carotid arteries belonging to 120 diabetic patients were studied (120 arteries each for RCCA, LCCA, RICA, and LICA) out of which 301 carotid arteries (62.7%) were normal (0% stenosis) and 179 (37.3%) were stenotic. The males had 110 (22.9%) stenotic carotid arteries while the females had 69 (14.4%) stenotic carotid arteries. The highest percentage stenosis was observed in LICA of a male patient. The observed range of percentage stenosis in common carotid arteries was 0 – 36% and 0 – 72% in the internal carotid arteries.

In total, 75 patients (62.5% of study population) had no stenosis in their carotid arteries; 38 (31.7%) had <50% stenosis in their carotid arteries; 6 (5.0%) had 50-69% stenosis of carotid arteries; and 1 (0.8%) had >70% stenosis in his carotid artery (LICA). Hence, the total number of diabetic patients with varying degrees of carotid artery stenosis observed in the present study was 45 (37.5% of total study population).



Sonographic Evaluation of Carotid Intima Media Thickness

Table 3: Frequency pattern of degree of stenosis in the carotid arteries of diabetic patients

Percentage degree of stenosis	Normal (0%)	<50%	50-69%	70%
RCCA Males	45 (37.5%)	27 (22.5%)	-	-
Females	31 (25.8%)	17 (14.2%)	-	-
LCCA Males	44 (36.7%)	28 (23.3%)	-	-
Females	30 (25%)	18 (15%)	-	-
RICA Males	44 (36.7%)	18 (15%)	10 (8.3%)	-
Females	30 (25%)	10 (8.3%)	8 (6.7%)	-
LICA Males	45 (37.5%)	15 (12.5%)	11 (9.2%)	1 (0.8%)
Females	32 (26.7%)	13 (10.8%)	3 (2.5%)	-

RCCA= Right common carotid artery; LCCA= Left common carotid artery;
RICA= Right internal carotid artery; LICA= Left internal carotid artery

Table 4 and figures 6 and 7 show the relationship between percentage degree of carotid artery stenosis with intima-media thickness (IMT) of the patients studied.

Positive and significant correlations were observed between the percentages degree of

stenosis of carotid arteries with IMT ($r= +0.5$; $p<0.05$) and flow velocities ($r= +0.5$; $p<0.05$) of carotid arteries with <50% and 50-69% stenosis. However, no significant correlations were noted in carotid arteries with no stenosis (normal) and 70% stenosis.

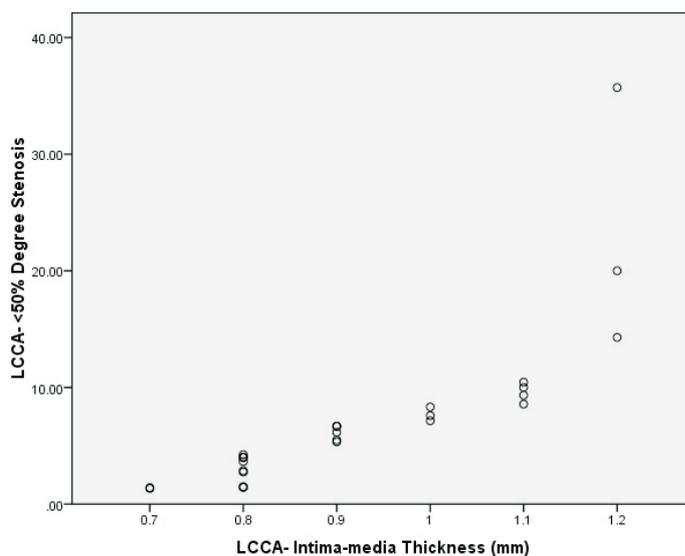


Figure 6: Scatter diagram showing a positive correlation between degree of stenosis and intima-media thickness in LCCA of diabetic patients with <50% degree stenosis.

Table 4: Correlation between intima-media thickness (IMT) and percentage degree stenosis in the carotid arteries of diabetic patients

IMT mean±SD (mm)	Normal (0%)	<50%	50-69%	70%
RCCA Males	0.76±0.08	0.92±0.18	-	-
Females	0.66±0.09	0.76±0.16	-	-
	<i>r</i> = -/-	<i>r</i> = +0.773 / +0.885	-	-
	<i>p</i> = -/-	<i>p</i> = 0.000 / 0.000	-	-
LCCA Males	0.75±0.07	0.92±0.25	-	-
Females	0.64±0.08	0.73±0.12	-	-
Males / Females	<i>r</i> = -/-	<i>r</i> = +0.804 / +0.877	-	-
Males / Females	<i>p</i> = -/-	<i>p</i> = 0.000 / 0.000	-	-
Total (RCCA+LCCA)	76 + 74 = 150	44 + 46 = 90	-	-
RICA Males	0.76±0.08	0.84±0.10	1.17±0.11	-
Females	0.66±0.07	0.77±0.12	1.14±0.08	-
Males / Females	<i>r</i> = -/-	<i>r</i> = +0.952 / +0.811	<i>r</i> = +0.898 / +0.903	-
Males / Females	<i>p</i> = -/-	<i>p</i> = 0.000 / 0.004	<i>p</i> = 0.000 / 0.002	-
LICA Males	0.73±0.07	0.82±0.09	1.12±0.17	1.40±0.00
Females	0.65±0.10	0.76±0.14	1.07±0.12	-
Males / Females	<i>r</i> = -/-	<i>r</i> = +0.931 / +0.813	<i>r</i> = +0.903 / +0.939	<i>r</i> = -/-
Males / Females	<i>p</i> = -/-	<i>p</i> = 0.000 / 0.001	<i>p</i> = 0.000 / 0.02	<i>p</i> = -/-
Total (RICA+LICA)	74 + 77 = 151	28 + 28 = 56	18 + 14 = 32	0 + 1 = 1

SD= Standard deviation; RCCA= Right common carotid artery; LCCA= Left common carotid artery; RICA= Right internal carotid artery; LICA= Left internal carotid artery; *r*= Correlation factor; *p*=P value

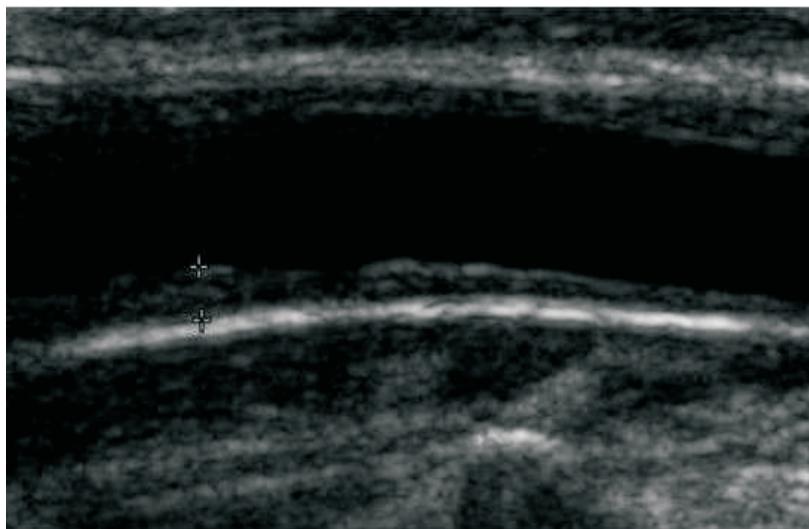


Figure 7: B-mode gray scale longitudinal sonogram showing thickened intima-media complex measuring 1.2mm in the common carotid artery.

DISCUSSION

Carotid arteries have been observed to be among the vessels that are prone to develop overt atherosclerotic lesions in the presence of risk factors such as diabetes mellitus and hypertension⁴³. The findings of the present study have shown that diabetes mellitus is associated with carotid artery stenosis and that ultrasonography is a useful tool in the evaluation of these arteries in diabetic patients. Adekanmi *et al*⁴⁴ have also observed that the diagnostic value of CDUS in detecting early carotid artery lesions that may progress to CVD is important when it comes to determining the degree of carotid artery stenosis and the approach to managing such cases.

This study revealed that of the 120 diabetic patients studied aged 20 years and above with a mean age of 50.02 ± 11.4 years, a large proportion was found in the age range of 40-49 years (35% of study population). The preponderance of middle aged population in this study was because of the fact that majority of people with type 2 diabetes in developing countries are in that age group range. Moreover, most of the diabetic patients attending the endocrinology clinic in the study centre fall within that age group. In addition to this fact, Sara *et al*⁴⁵ in their study on the global prevalence of diabetes have also documented the increasing incidence of diabetes in these age groups due to population growth, urbanization, increasing prevalence of obesity and physical inactivity. They also reported that data on diabetes in the younger age group is limited.

Although there is paucity of literature regarding the normal values for intima-media thickness (IMT) in Nigerians and Africans in general, this study has observed that the overall mean carotid IMT in diabetic patients in the non-stenotic right and left carotid arteries were (CCA= 0.71 ± 0.09 mm and 0.70 ± 0.08 mm; ICA= 0.71 ± 0.08 mm and 0.69 ± 0.09 mm) respectively.

The stenotic carotid arteries mean IMT on the right and left were (CCA= 0.84 ± 0.17 mm and 0.83 ± 0.12 mm; ICA= 0.98 ± 0.10 mm and 1.03 ± 0.10 mm). The IMT means from the present study were higher when compared with previous studies in normal subjects where the range of carotid IMT was found to be from 0.2mm to 0.7mm^{36,43,46-48}. The present study found the range of IMT for the carotid arteries to fall between 0.5mm to 1.3mm. In a related study amongst type-2 diabetic patients in Japan by Naomi *et al*⁴⁹, it was also reported that carotid artery IMT was significantly greater in diabetic patients than non-diabetic patients. Handa *et al*⁶ have also defined carotid atherosclerosis as an IMT measurement of >1.0 mm. Mean IMT of >1.0 mm was also observed in the present study. Brian³⁹ also stated that CCA IMT of >0.87 mm and ICA IMT >0.90 mm are associated with progressively increased risk of cardiovascular events.

It was also observed, in the present study, that the overall non-stenotic (normal) IMT values in males (CCA = 0.76 ± 0.09 mm; ICA= 0.75 ± 0.10 mm) were higher than the ones found in females (= 0.61 ± 0.15 mm; ICA= 0.65 ± 0.10 mm). This difference in IMT between the sexes studied was statistically significant. These observations were in conformity with the findings in previous studies^{36,49}. However, Huseyin *et al*⁵⁰ stated that there was no significant difference between the sexes with respect to IMT.

The present study has also observed that percentage degree of stenosis correlated positively and significantly with IMT ($r= 0.5$; $p<0.05$) of carotid arteries in both males and females. These findings corroborated with those of other workers who reported on carotid atherosclerosis^{1-3,11,13,19,28,51}.

The report by the Society of Radiologists in Ultrasound (SRU) Consensus Conference in 2003^{38,39} regarding the grading of degree of carotid artery stenosis has made the following statements: the degree of stenosis determined



at gray scale and Doppler ultrasonography should be stratified into the categories of normal (no stenosis), <50% stenosis, 50-69% stenosis, 70% stenosis to near occlusion, near occlusion, and total occlusion. The SRU also added that ICA is normal when its peak systolic velocity (PSV) is less than 125cm/sec and no plaque or IMT thickening is visible; (ii) <50% stenosis when ICA PSV is less than 125 cm/sec and plaque or intimal thickening is visible; (iii) 50%–69% stenosis when ICA PSV is 125–230 cm/sec and plaque is visible; (iv) 70% stenosis to near occlusion when ICA PSV is greater than 230 cm/sec and visible plaque and lumen narrowing are seen; (v) near occlusion when there is a markedly narrowed lumen at colour Doppler US; and (vi) total occlusion when there is no detectable patent lumen at gray-scale US and no flow at spectral, power, and colour Doppler ultrasonography.

Doppler spectral observations made in the present study were unremarkable as majority (62.5%) of the patients with stenotic carotid arteries clustered around <50% stenosis and few (5.0%) had 50-69% carotid stenosis. Flow velocity findings were more sensitive for displaying carotid stenosis on the Doppler waveforms. In addition, some studies have shown that spectral broadening and filling of the window under the spectrum are subjective especially in carotid stenosis of <50%.^{7,11,13,16,42,52}. Moreover, carotid stenosis usually begins to show remarkable spectral waveform changes from turbulent blood flow when the stenosis exceed 70%.^{13,16}. This was evident in this study as only the male patient with 72% degree stenosis of the LICA had moderate spectral broadening in his Doppler waveform with evidence of increased flow velocities (PSV=390.0cm/sec; end diastolic velocity; EDV=115.0cm/sec).

The present study adopted the stratification of carotid artery stenosis given by SRU because of its simplicity and suitability to the present study. It was observed that a total of 75

patients (62.5% of study population) had no stenosis in their carotid arteries; 38 (31.7%) had <50% stenosis in their carotid arteries; 6 (5.0%) had 50-69% stenosis of carotid arteries; and 1 (0.8%) had >70% stenosis in his carotid artery (LICA).

The observed prevalence of carotid stenosis in the present study was found to be 37.5% of the total study population. In a retrospective study using CDUS by Razzaq *et al*⁵³ in 45 diabetic patients diagnosed of stroke, they found carotid artery stenosis >50% in 31% of their study population. Noor *et al*⁵⁴ in their study of 100 patients with ischaemic infarction found 44% of the patient to be diabetic and that 56% of the diabetic patients in their study had carotid artery stenosis as detected by CDUS.

The present study and those of previous researchers^{27,53} have, therefore, shown that diabetic patients are prone to develop carotid artery atherosclerosis that may be a cause of stenosis in these arteries. Hence, the clinical value of DUS as an imaging modality in the management and prevention of cerebrovascular diseases, especially in diabetics, is indispensable. Therefore, the ability to quickly and efficiently identify carotid stenosis in patients at risk, using DUS is of clinical importance. Identification of potentially treatable carotid stenosis enables selection and appropriate placement of patients for stent implantation or carotid endarterectomy.

CONCLUSION

This study has shown that carotid duplex ultrasonography (CDUS) is an important imaging modality for early detection of carotid artery stenosis in diabetic patients who are at risk for developing carotid atherosclerosis. CDUS has established its role in screening and diagnosis of carotid artery disease because of its safety, low cost, and accuracy in detecting carotid artery disease. The findings of this study have substantial implications for clinical



practice and public health especially with regards to cerebrovascular disease prevention in diabetic patients. The study has, therefore, provided useful baseline data on which subsequent radiological and clinical interventions may be based.

RECOMMENDATIONS

1. Multi-centred approach to the study is essential to validate the values and to help in establishing standard reference values for carotid artery dimensions in this environment.
2. Carotid Duplex ultrasonography is a norm for patients with diabetes, hypertension, and other diseases considered to be risk factors for cerebrovascular disease (CVD) in other centres. It should, therefore, be made mandatory as a screening tool in diabetic patients especially in those suspected of having features of CVD.
3. Carotid Duplex ultrasonographic studies should be considered in the future in other patients with risk factors for stroke especially hypertensive and sickle cell disease patients in this environment.

LIMITATIONS OF THE STUDY

1. Physical challenges such as a short muscular neck and high carotid bifurcation. This was minimized by asking such patients to extend their neck as high as comfortably possible.
2. Occasionally there was difficulty in adequate visualization of the carotid arteries in obese patients. Improved visualization was made possible by use of higher frequency transducer.
3. Because of the long duration of examining each carotid artery, some of the patients tend to be uncooperative while being scanned or as they wait for their turn to be scanned. In such cases adequate counselling as regards the importance of the outcome of the study to the management of diabetics was highlighted to such patients.
4. There was no previous study for validating the measurements of the carotid arteries in this environment.

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